



**Jet Propulsion Laboratory**  
California Institute of Technology

# Snow Stratigraphy using Tomography Radar

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# Overview

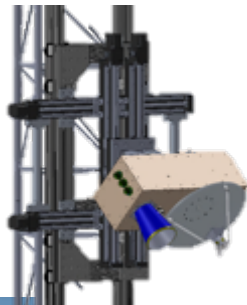
- Introduction
- Tomography Radar System
- Deployment at Fraser, CO
- Calibration
- Preliminary results
- Summary

# Introduction

- Snow Stratigraphy
  - Traditional measurement: Snow pit
  - Snow reflectance mapping (NIR photography)
  - Tomography (2D image)

# Tomography Radar System

1. Three frequencies FMCW radar centered at 9.6 GHz, 13.5 GHz, and 17.2 GHz
2. The transceiver is mounted to a dual-axis planar scanner (60cm in each direction), which creating a tomographic baseline in two directions.
3. Dual-antenna architecture was implemented to improve the isolation between the transmitter and receiver.

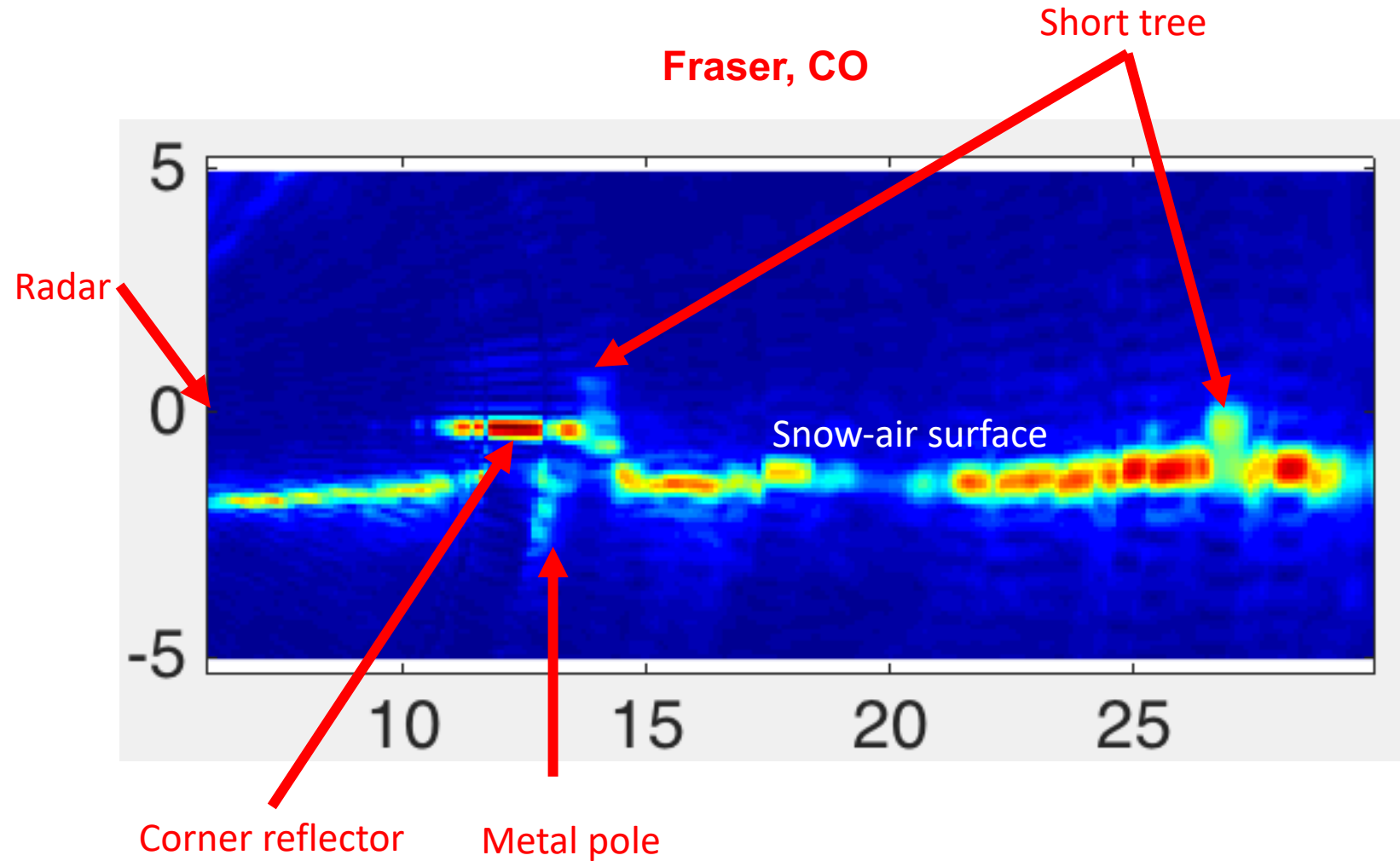


# Deployment at Fraser, CO

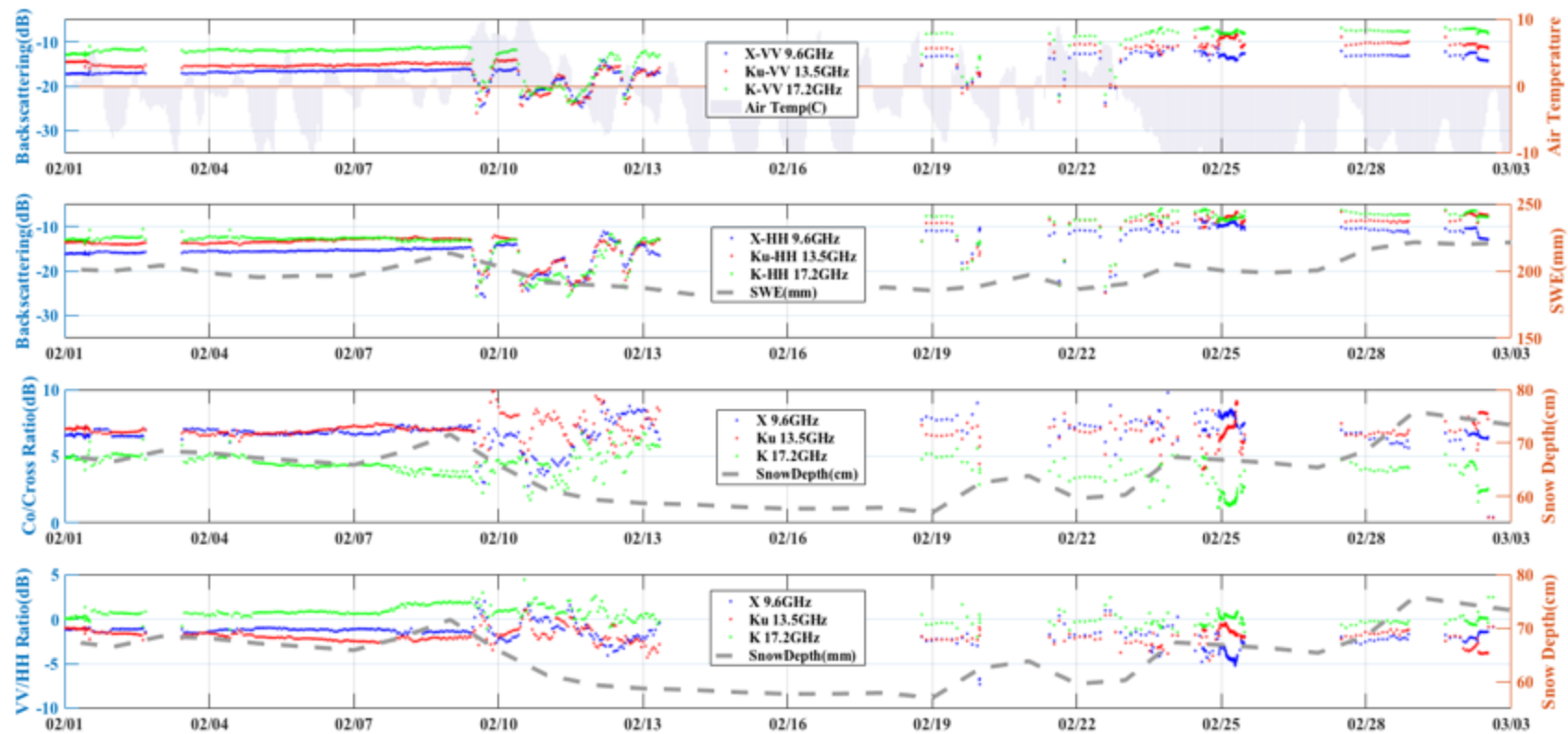
- The system was deployed on a ground based tower at the Fraser Experimental Forest (FEF) Headquarters, near Fraser, CO, USA ( $39.847^{\circ}\text{N}$ ,  $105.912^{\circ}\text{W}$ )
- In situ measurements of snow depth and other snowpack properties were performed every week for comparison with the remotely sensed data



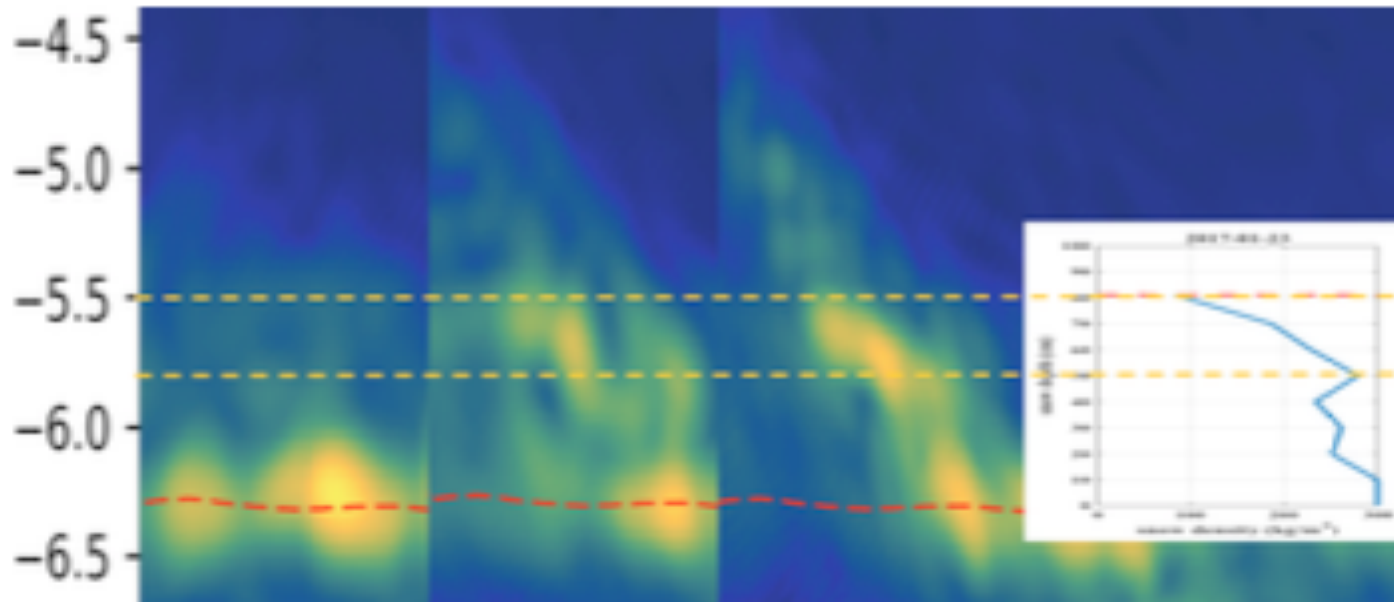
# Calibration with corner reflector



# Time-series analysis



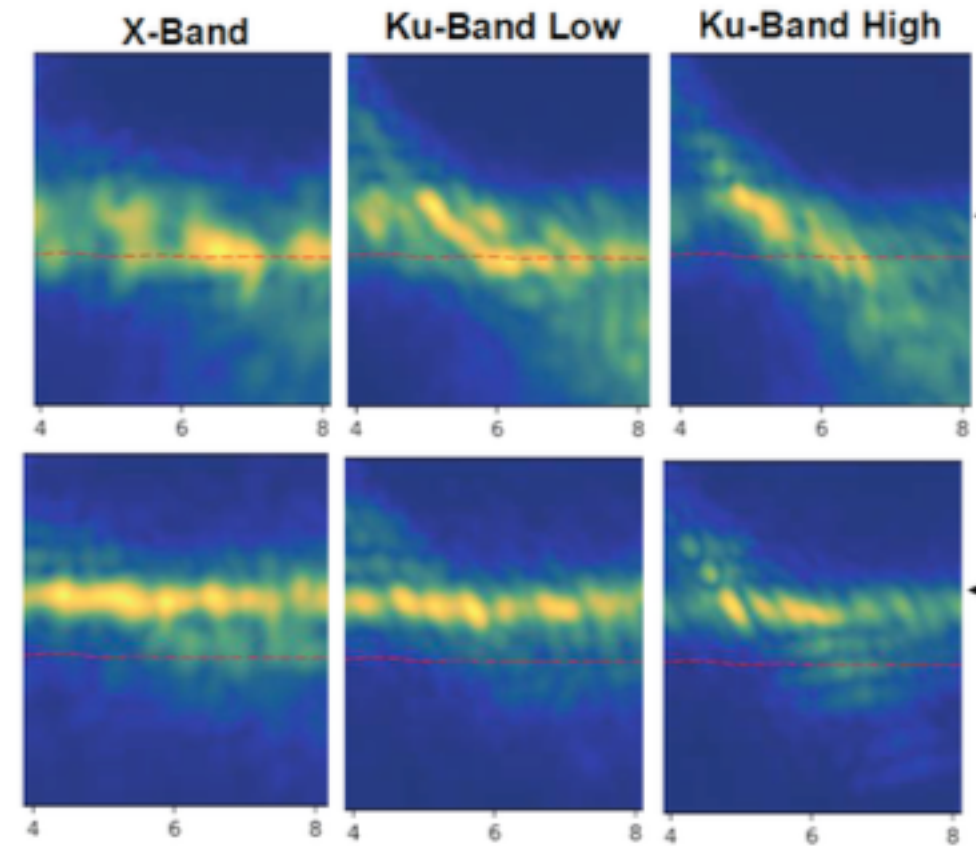
# Snow Stratigraphy from Tomograms



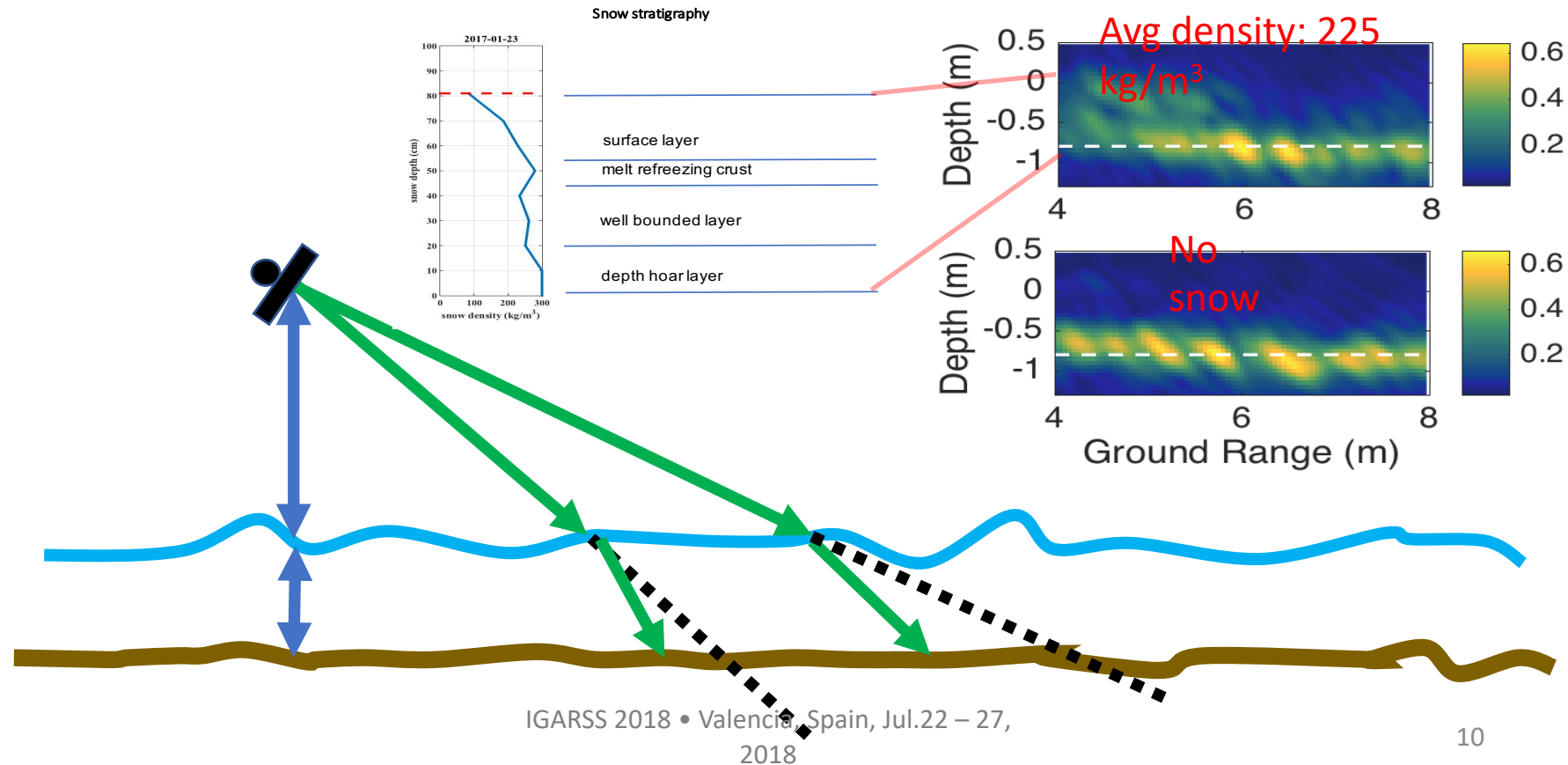
- The red line is ground reference position derived from the snow-free laser measurement. The plot demonstrates the coherency of the vertical slice. As the frequencies increases, the volume scattering from the snow become more prominent. The snow density of the pit measurement also matches coherency distribution.

# Diurnal Thawing and Refreezing Cycle

- In February, there are a few warmer days. The snow went through thawing and refreezing process during a day. The tomograms shows that when the snow is wet, the higher coherency shifted from snow-ground interface to air-snow interface due to the high permittivity contrast between wet snow and air

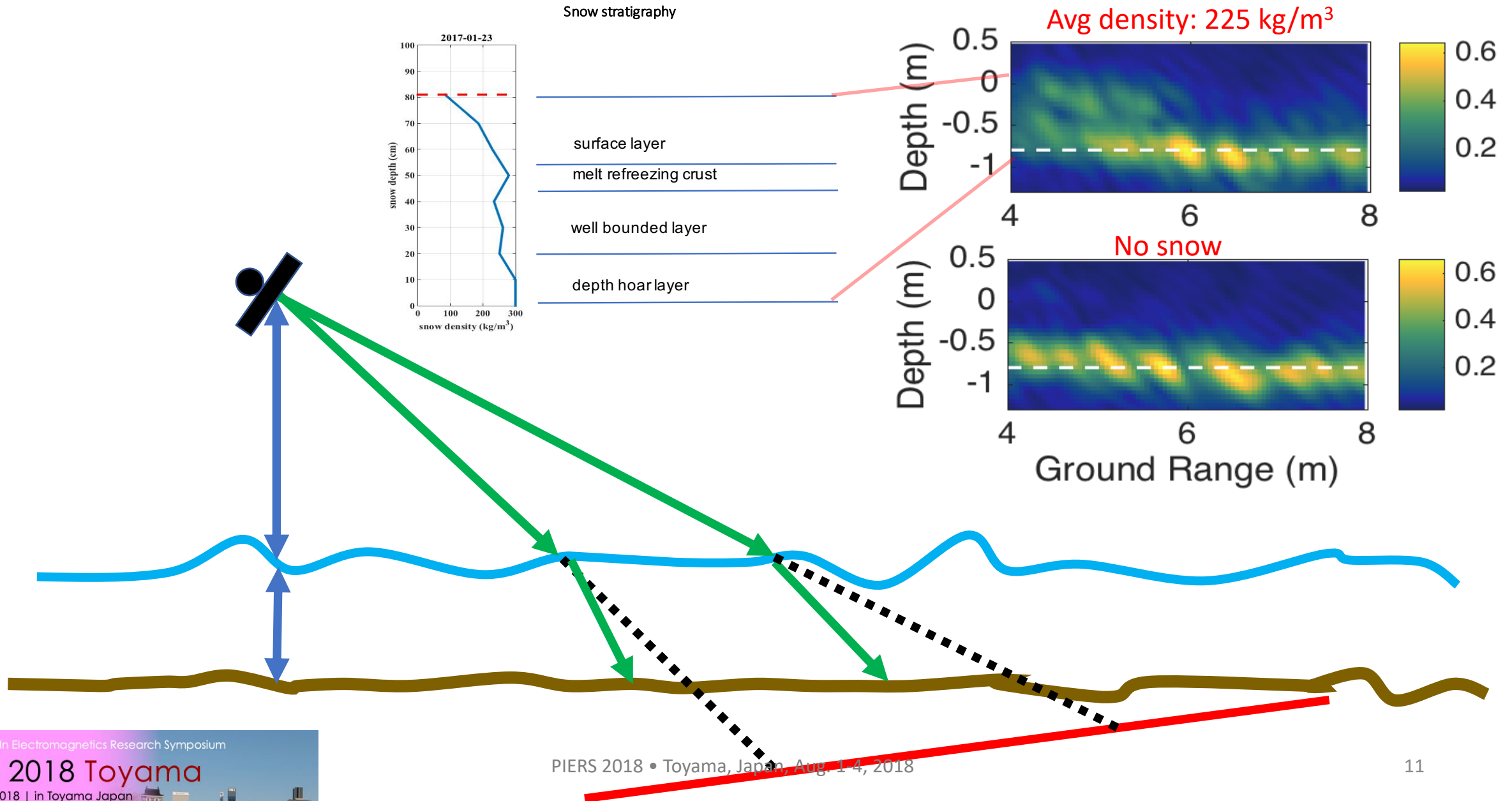


# Snow water equivalence retrieval



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# Snow Water Equivalent (SWE) retrieval



# Future work

- Enhance the resolution from 30 cm to 10 cm for better accuracy of SWE retrieval
- Deploy calibration targets in the test site
- Test various radar techniques for SWE retrieval: SAR tomography, InSAR/PolInSAR, etc
- Temporal change monitoring through the whole winter using various radar measurements
- Cross-validate other field & remote sensing data at the Fraser site